4. Cuneiform lies in front of corniculate in the aryepiglottic folds.

Developmental aspect of Cartilages – all are mesodermal in derivative.

1. *Epiglottis* – from fourth arch
2. *Thyroid* – from fourth or by fusion of fourth and fifth arches
3. *Cricoid* – from sixth arch
4. *Arytenoid* – from sixth arch
5. *Corniculate and Cuneiform* – sixth arch as they are said to be detached part of arytenoid (But some are of opinion cuneiform is derived from fourth arch)

Joints of Larynx – usually two :

I. **Cricothyroid Joint** – A pair of joints between Thyroid cartilage and Cricoid.

A. ***Type*** – Synovial.

B. ***Bones taking part*** – (a) Inferior horn of thyroid cartilage and (b) Facet on the side of cricoid.

C. ***Ligaments*** – Covered by a fibrous capsule strengthened by a fibrous band.

D. ***Important relation*** – Recurrent laryngeal nerve passes behind the joint to enter the larynx.

E. ***Movements***

(a) Rotation of Cricoid on both the Inferior horns around a transverse axis.

(b) Limited gliding movements in different directions.

II. **Cricoarytenoid Joints**

1. These are paired joints between cricoid and arytenoid cartilages.
2. ***Type*** – Synovial.
3. Bones taking part are (a) deep grooved bases of arytenoid and (b) Facets on the lateral part of upper border of lamina of Cricoid cartilage.
4. Enclosed by a capsular ligament and presence of strong posterior cricoarytenoid ligament.
5. ***Movements*** –

(a) Rotation of arytenoid around an oblique axis and the effect is Swinging of Vocal process laterally or medially resulting in increase or decrease of Rima Glottidis.

(b) Gliding – It helps in approaching or receeding of arytenoid from each other. These two movements combine to form lateral rotation with lateral gliding and medial rotation with medial gliding, forward movement is limited by posterior cricoarytenoid ligament.

(c) This ligament helps in slight Pivotal momentum.

Ligaments of Larynx

They are divided into two groups :

I. **Extrinsic** – Those which connect among Thyroid, Cricoid and Epiglottis.

They are – Thyrohyoid membrane, Hyoepiglottic and cricotracheal ligaments.

1. **Thyrohyoid membrane** with median and lateral thyrohyoid ligaments.

(a) They connect the upper border of thyroid cartilage with superior horn below to upper border of Hyoid bone with greater cornu above.

(b) **Median thyrohyoid ligament** – The median thickest part and lateral thyrohyoid ligament is the cord like structure at the posterior margin of thyrohyoid membrane. Cartilago Triticea is usually present in each ligament.

(c) **Structures piercing thyrohyoid membrane** – are Superior laryngeal vessels and Internal laryngeal nerve [pierce the thin part on each side of median thyroid ligament]

2. **Hyoepiglottic ligament** – Connecting Epiglottis with hyoid bone.
3. **Cricotracheal ligament** – Ligament connecting lower border of Cricoid cartilage with first ring of trachea.

II. **Intrinsic** – These ligaments are derived from Fibro-elastic membrane of the larynx which is a broad sheet of mucous membrane in the submucous region.

This fibroelastic membrane is divided into two parts by sinus of larynx (within cavity of larynx).

I. **Upper Quadrangular**, II. **Lower Crico-thyroid or Cricovocal membrane** (Conus Elasticus).

Quadrangular or Quadrate membrane

1. Upper fibroelastic sheet of mucous membrane of larynx extending between arytenoid and epiglottis.
2. The lower border becomes thickened to form vestibular ligament and upper border forms aryepiglottic fold.

Crico-vocal or Cricothyroid ligament (Conus elasticus)

1. Lower fibro-elastic sheet of mucous membrane extending adjacent margins of cricoid and arytenoid cartilages.
2. It consists of two parts :
   A. Median larger thicker part is actually known as Median or Anterior Cricothyroid ligament
   B. Lower lateral small part is lateral Cricothyroid ligament
   C. The upper margin becomes condensed to form Vocal ligament

Interior of Larynx or Cavity of Larynx

Extent – It extends from inlet of larynx to lower border of cricoid cartilage.

Walls of the cavity – Anterior and posterior wall. Due to obliquity of the inlet the anterior wall is more in length than the posterior wall.

Different folds of mucous membrane within the cavity – Three folds from above downward are present. They are : 1. Aryepiglottic, 2. Vestibular, 3. Vocal folds.

Fissures or spaces between the paired folds – Three spaces :

1. *Inlet of Larynx* – space between two aryepiglottic folds
2. *Rima Vestibuli* – space between two vestibular folds
3. *Rima Glottidis* – space between two vocal folds

Different subdivisions – Cavity of larynx is divided into three parts by two pair of folds – Vestibular and Vocal folds.

1. *Vestibule or upper part* – Part above the vestibular folds (From aryepiglottis to vestibular)
2. *Intermediate part or Sinus of larynx (also known as ventricle)* – Part between vestibular folds above and vocal folds below.

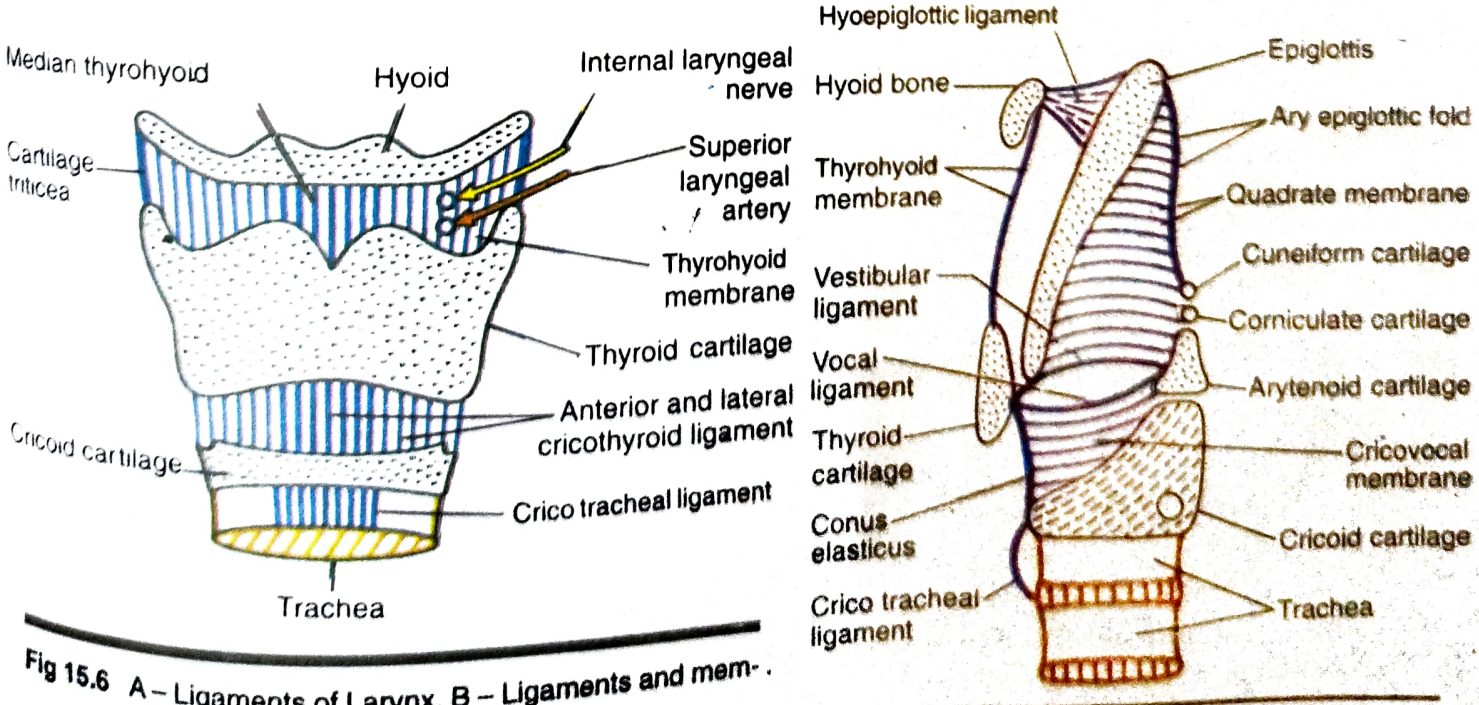

Fig 15.6 A – Ligaments of Larynx, B – Ligaments and membranes of Larynx.

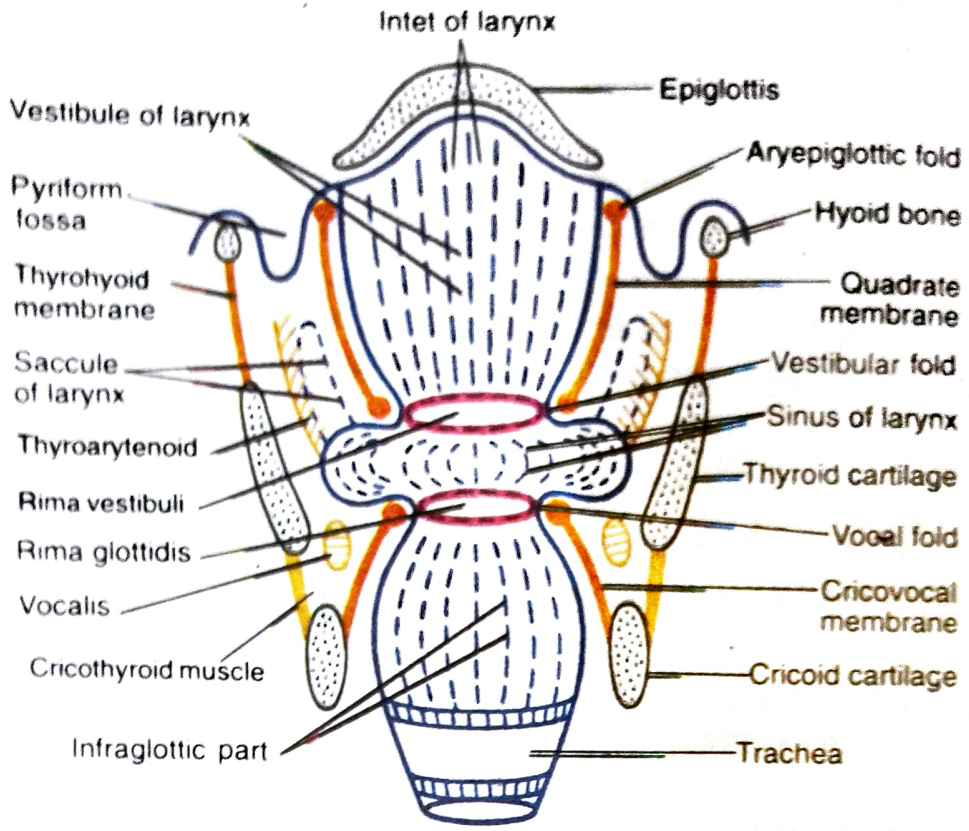

Fig 15.7 Arytenoid and Posterior lamina of Cricoid, B – Lateral aspect.

3. *Infraglottic or lower part* – Below the vocal folds. It is featureless but lined by loose mucous membrane.

Inlet of Larynx

1. It is the opening of entrance of larynx through which larynx opens into the laryngo-pharynx.
2. **Boundary**
   - A. *In front* – Upper border of Epiglottis
   - B. *Behind* – Interarytenoid folds (mucous folds)
   - C. *On each side* – Aryepiglottic folds. In the posterior part two elevations are present and they are due to cuneiform in front and corniculate cartilages behind.
3. **Slope of Inlet** – Downwards and backwards.
4. A. Closure – By approximation of aryepiglottic folds and by bringing the arytenoid cartilages close to epiglottis due to contraction of Aryepiglotticus.
   B. Opening – By Thyroepiglotticus.

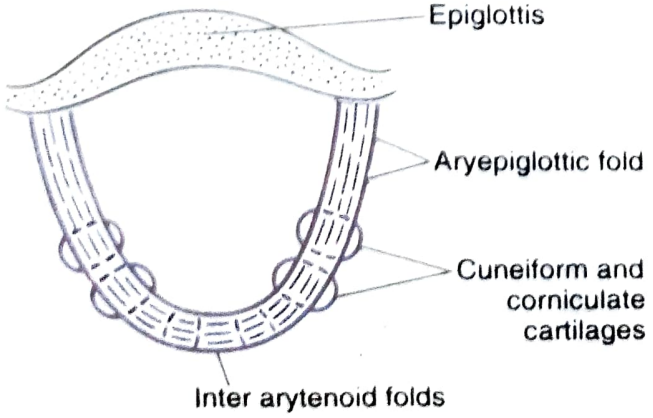

Fig 15.8 Inlet of Larynx.

Vestibule of Larynx

1. It is the upper part of larynx between Inlet of larynx above and Vestibular folds below.
2. It is wider above, narrower below and anterior wall is longer than posterior wall.
3. **Boundary**
   - A. *Anterior wall* – Posterior surface of Epiglottis
   - B. *Posterior wall* – Interarytenoid mucous membrane above vestibular folds
   - C. *Lateral wall* – Medial surface of aryepiglottic folds. It is deeper above and shallower below.
4. It acts as a resonating chamber.

Ventricle or Sinus of Larynx

1. It is the middle part of cavity of Larynx and is the smallest of three divisions and the part

between Rima vestibuli above and Rima glottidis below.

2. It presents a deep mucous recess extending to lamina of Thyroid cartilage.
3. Lining of sinus may bulge forwards due to absence of cricovocal membrane and quadrangular membrane.
4. Opening of Saccule is present on anterior part of each side.

Saccule of Larynx

1. A mucous diverticulum arises from anterior part and on each side of sinus of larynx.
2. It extends blindly upwards between the vestibular fold and lamina of Thyroid cartilage. It may go beyond thyroid cartilage and Thyrohyoid membrane in neck and upto axilla in some animals.
3. The wall is studded with 60–70 mucous glands. Secretions of these glands lubricate the Vocal fold particularly during production of voice. So it is called "oil can" for "Vocal fold".
4. In those animals (as in Apes) where it may extend upto axilla, they conserve air within this for future use and may act as resonance of Voice.

Rima Vestibuli – It is a space or fissure between two vestibular folds which are folds of mucous membrane containing vestibular ligaments (lower condensed part of quadrate membrane).

Action –

1. It acts as exit valve so that it allows entry of air during inspiration but prevents exit of air during expiration.
2. It increases intrathoracic and intraabdominal pressure which is essential for act of coughing, micturition, defecation and parturition (in female) and this is done by withholding of breath at the end of inspiration.

Vestibular folds – (Also known as Ventricular fold or False Vocal cord).

1. They are paired and one on each side demarcating upper part or vestibule of larynx and middle or sinus of larynx.
2. **Formation**– Each is a fold of mucous membrane containing vestibular ligament which is lower condensed and thickened free lower margin of quadrate membrane.
3. It slopes downwards and medially.
4. Each is lined by ciliated columnar epithelium with submucous areolar tissue.
5. **Arterial supply** – By Superior laryngeal branch of Superior thyroid branch of external carotid.
6. **Nerve supply** – Internal laryngeal branch of Superior laryngeal (branch of Vagus)

Rima Glottidis (Glottis) – Broadly it is a space between two vocal folds.

Features –

1. It is the narrowest part of the larynx.
2. It is a fissure antero-posteriorly.
3. It is longer in male than female

   In Male – 23 mm

   In Female – 17 mm
4. **Boundary**
   A. *In front* – Angle of Thyroid cartilage
   B. *Behind* – Mucous fold between two arytenoid cartilages
   C. *Laterally* – Vocal fold in front and vocal processes behind.
5. *Different Parts* – Two:
   A. *Intermembranous Part* – Anterior 3/5th of the space and between two vocal folds.
   B. *Intercartilaginous Part* – Posterior 2/5th of the space between vocal processes of arytenoid cartilages.

Shape and appearance of Rima glottidis – It depends upon type of breathing and phonation.

I. **During quiet breathing** and **at Rest**, Intermembranous part is triangular and the intercartilaginous part is quadrangular between the medial surfaces of arytenoid cartilage.

II. **During forced Inspiration** – Intermembranous part triangular but wide apart due to abduction of Vocal folds and Intercartilagi-

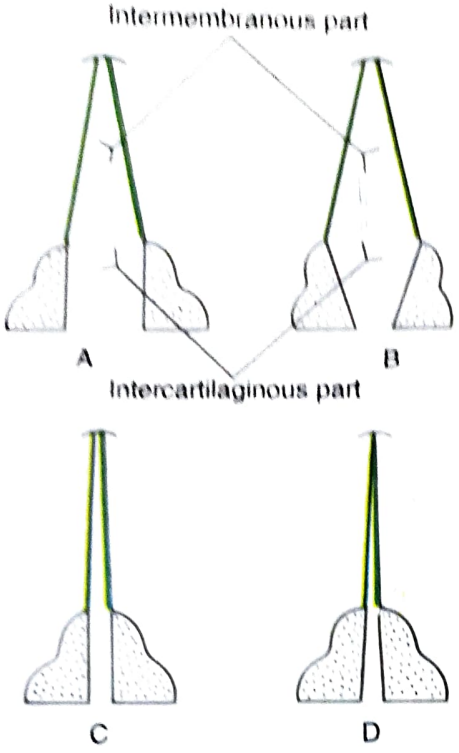

Fig 15.9 Rima glottidis : A – At rest and quiet respiration, B – During forced inspiration, C – During phonation — high pitched sound production, D – During whispering.

nous part becomes triangular due to lateral rotation of arytenoid cartilages. Rima glottidis is diamond shaped.

III. **During Phonation and production of high pitched sound** Rima glottidis becomes a narrow chink as vocal folds adducted and arytenoids become medially rotated.

IV. **During Whispering** – Intermembranous part becomes closed but Intercartilaginous remains open.

Action of Rima Glottidis

1. As Entry Valve – It allows exit of air during *expiration but prevents entrance of air during inspiration.*

This valve action is due to upward and medial direction of vocal fold.

This is required for holding the breath at the end of expiration in order to have free movements of arm by inspiratory muscles as Serratus anterior and Pectoralis major.

2. **Production of Voice** – During expiration air produces vibration of vocal folds and produces sound. Voice produced by Vocal folds are Vowels and not the consonants. It also produces tone having basic pitch of the sound.

Vocal folds (known as Vocal Cords)

1. They are paired folds of mucous membrane containing vocal ligament (upper condensed and thickened free margin of cricovocal membrane) medially and Vocalis muscle laterally.
2. The free margin of folds look upward and medially.
3. **In living condition** – it appears pearly white as it is least vascular.
4. It is lined by stratified squamous epithelium without any submucous tissue and so mucous membrane is more or less intimately adherent to underlying ligament.
5. It is lubricated by mucus from glands of Saccule.
6. Both the folds form Rima glottidis and demarcate middle part above and infraglottic part of larynx below.
7. **Arterial supply** – By both superior and inferior laryngeal arteries.
8. **Nerve supply** – By both internal and recurrent laryngeal nerves.

Intrinsic Muscles of Larynx

1. **Cricothyroid**

Origin – From lower border and lateral surface of cricoid.

Insertion – Lower border and inferior cornu of thyroid cartilage.

Action – Tensor of vocal folds.

2. **Posterior Cricoarytenoid**

Origin – From posterior surface of Cricoid lamina.

Insertion – Muscular process of arytenoid.

Action – Abductor of vocal cord.

3. **Lateral Cricoarytenoid**

Origin – From lateral aspect of upper margin of anterior arch of cricoid.

Insertion – Into muscular process of arytenoid.

Action – Adductor of vocal cord.

Tranverse arytenoid

Origin – From posterior surface of arytenoid of one side.

Insertion – To posterior surface of arytenoid of other side.

Action – Adductor of vocal cord.

Oblique arytenoid

Origin – From muscular process of arytenoid.

Insertion – To apex of other arytenoid.

Action – Closing the inlet of larynx.

Aryepiglotticus – Few fibres of Oblique arytenoid from the apex of arytenoid continue to edge of epiglottis and known as Aryepiglotticus.

Action – Closing inlet of larynx.

Thyroarytenoid

Origin – From thyroid angle and cricothyroid ligament.

Insertion – Into antero-lateral surface of arytenoid cartilage.

Action – Relaxing vocal cord.

Vocalis – Those fibres of Thyroarytenoid from arytenoid cartilage extending to vocal fold are called Vocalis.

Action – Relaxation of Vocal cord.

Thyroepiglotticus – This consists of fibres of Thyroarytenoid from arytenoid cartilage extending in a curved manner into the aryepiglottic fold and ultimately to margin of epiglottis.

Action – Opening of Inlet of larynx.

Grouping of Intrinsic muscles according to action

I. **Acting on Inlet of Larynx**
   - A. *Closing* –
     - (a) Oblique arytenoids
     - (b) Aryepiglotticus
   - B. *Opening* – Thyro-epiglotticus

II. **Acting on Vocal Cords and on Rima glottidis**
   - A. *Abductor of Vocal Cord and thus opening of glottis*
     - Posterior cricoarytenoid – only abductor (safety muscle of larynx).
   - B. *Adductor of Vocal Cord and closure of glottis*
     1. Lateral Cricoarytenoids
     2. Transverse arytenoids
   - C. *Tensor of Vocal Cord* – Cricothyroids
   - D. Relaxing Vocal Cord
     1. Thyroarytenoid
     2. Vocalis

Safety muscle of Larynx – Posterior cricoarytenoid is called safety muscle of larynx. It is the only abductor muscle of larynx. If this becomes paralysed, the adductor muscles will close the glottis and the person may be subjected to death due to suffocation. So Posterior cricoarytenoid muscle due to its action of abduction is saver of life and so called Safety muscle of larynx.

Nerve supply of muscles – All the intrinsic muscles except Cricothyroid are supplied by *Recurrent laryngeal nerve*. *Cricothyroid* is supplied by external laryngeal nerve.

Mucous membrane and lining epithelium of Larynx

A. *Epithelium* – The whole of mucous membrane of larynx is lined by *pseudo-stratified ciliated columnar epithelium* except the areas below lined by *stratified squamous epithelium*.
   - (a) Aryepiglottic fold
   - (b) Upper part of posterior surface of epiglottis
   - (c) Vocal fold.

B. Taste buds in the epithelium – present in aryepiglottic fold, vestibular fold and also in epiglottis.

Arterial supply

A. Above the vocal fold – Superior laryngeal branch of Superior thyroid artery.

B. Below the Vocal fold – Inferior laryngeal artery branch of Inferior thyroid artery.

C. Vocal fold – Both the above arteries.

Veins – Correspond to arteries.

Lymphatics –

A. *Above the vocal fold* – drains into prelaryngeal and jugulo-digastric lymph node.

B *Below the vocal fold* – drain into pre and paratracheal group of lymph nodes.

C. *At the vocal fold* – Lymphatics drain into both the above ways and act as water shed line.

Nerve supply of Larynx –

Motor –

(a) Except Cricothyroid all muscles are supplied by recurrent laryngeal nerve.

(b) Cricothyroid – By external laryngeal branch of Superior laryngeal branch of vagus.

(c) Transverse arytenoid has double nerve supply. By both recurrent laryngeal and internal laryngeal branch of superior laryngeal nerve.

Sensory – Mucous membrane above the vocal fold by Internal recurrent laryngeal nerve and below the vocal fold by recurrent laryngeal nerve. Vocal fold by both the nerves.

Secretomotor – Laryngeal glands by recurrent laryngeal nerve mainly.

Development – Mucous membrane is endodermal and from cranial part of laryngo-tracheal diverticulum which arises from ventral aspect of pharyngeal part of foregut.

Mechanism of production of Voice (Phonation)

Four processes produce the voice

1. Expired air from the lungs initiate and also responsible for intensity and loudness.
2. Vibration of vocal folds by the expired air – responsible for pitch of voice.
3. Resonation by column of air from lip and nostrils to Vocal fold responsible for quality and vowels.
4. Articulation by lips, tongue, teeth and palate. Mainly consonants are produced.

Tensor of Vocal fold – Mechanism : It is mainly by elongation of Cricothyroid.

Consensus opinion – Contraction of muscle rotates the anterior arch of cricoid upwards towards Thyroid cartilage and simultaneously the posterior lamina is rotated backward along with backward displacement of arytenoid cartilages and the ultimate result is increase in distance between Thyroid cartilage and vocal process and so *Vocal fold is lengthened and under tense condition.*

Negus View – Contraction of Cricothyroid causes forward movement of thyroid cartilage and cricoid cartilage remains fixed and as a result the distance between angle of thyroid and vocal process becomes increased and produces tension of Vocal folds.

Applied –

I. Paralysis of Recurrent laryngeal nerve and effects on larynx

A. When nerve of one side is involved (during partial thyroidectomy). The affected vocal fold is paramedian in position and the unaffected vocal fold moves freely to the opposite vocal fold

(i) Voice – hoarse

(ii) Respiration – No difficulty.

B. In case of paralysis of both the recurrent laryngeal nerves. Both the folds are more or less fixed in paramedian in position. The person complains of :

(i) Difficulty in respiration

(ii) Difficulty in production of voice

To releive Tracheostomy will be the choice of treatment.

C. If Recurrent laryngeal and External laryngeal nerves are involved – the vocal folds are in cadaveric position (further abducted and fixed).

D. **Semon's Law** – It is manifested in chronic type of paralysis of recurrent laryngeal nerves i.e. slowly growing tumour pressing upon the nerve.

According to this Law – Abductors are involved first and other muscles follow. During recovery Adductor recovers last.

It is probably due to thickly myelinated fibres

supply the abductors and these nerve fibres are affected by oxygen lack as a result of pressure.

II. *Vocal fold is least vascular and submucous tissue is absent.* So during inflammation there will be lesser oedema larynx and chance of suffocation is least. Besides, due to phonation vocal folds vibrate and due to less amount of blood supply there will be least chance of bleeding.

III. *Foreign body* may be lodged due to narrowness (narrowest part of respiratory tract) but if passes it will pass through trachea and bronchi easily and may be caught in a narrow bronchiole.

IV. *Laryngeal oedema* may be allergic or infective due to inflammation and may cause pain, dyspnoea with inspiratory stridor and fatal result may occur due to asphyxia.